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Soil arthropod numbers and biomass in two pine forests on different soils, related to functional groups

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With one figure

Synopsis: *Original scientific paper*

Two related pine forests were characterized as a mor and a mor/moder forest. Mesofauna populations of collembolans and oribatid mites in these two forest soils were compared on the basis of their numbers and their biomass during both the spring and late summer period. This was done for the most numerous taxa and for functional groups of these taxa, with the aim to relate arthropods species distribution to differences in forest characteristics.

It is shown that in the mor forest a more diverse mesofauna community is found. In spring both forests have one dominant collembolan species; in the mor forest *Lepidocyrtus lanuginosus* and in the mor/moder forest *Isotoma notabilis*. In late summer *Tomocerus minor* becomes very abundant in both forests. For oribatid abundance the mor forest shows a more diverse distribution. In the mor/moder forest one species *Platynothrus peltifer* is dominant. Results are found to be strongest for biomass, compared to animal numbers.

With reference to functional groups, the mor forest consists of significantly more epigeic collembolans and food specialist oribatids, viz. macrophatophagous and microphytophagous species. In the mor/moder forest the hemiedaphic collembolans and the non-specialistic panphytophagous oribatids are significantly more abundant.

It is concluded that the arthropod species distribution and abundance is related to the small differences in forest characteristics.

Key words: Mor, moder and mull litter – mesofauna – collembolans – oribatids – number and biomass – functional groups.

1. Introduction

The classic classification of litter types in 'mor' and 'mull', mediated by a 'moder' type (MÜLLER, 1884), is used by SWIFT *et al.* (1979), HÅGVAR (1984), HÅGVAR & ABRAHAMSEN (1984), KANEKO (1985), and TAKEDA (1987). Characteristic for mor litter types is a clear zonation between the mineral soil and the organic layers and, particularly in coniferous forests, between the sublayers of the litter. Mull litter types show no sharp division between the organic and mineral soil and have a non-stratified litter layer. Mor litter have low earthworm and macrofauna populations and high mesofauna populations, a C/N and C/P ratio above 27 and 600, respectively (KUNTZE *et al.*, 1988), and are often found on relative nutrient poor, acid soils. Mull litter have relatively high earthworm and macrofauna populations and low mesofauna populations, a C/N ratio between 10 and 17, and a C/P ratio lower than 200 (KUNTZE *et al.*, 1988), and are often found on relatively nutrient rich, neutral to basic soils. Further characteristics for both litter types are given by WALLWORK (1970) and SWIFT *et al.* (1979). These differences in nutrient quality for mor and mull have strong influences on the functioning of the total ecosystem (REICHLE, 1971). Although vegetation and litter type do not always affect the community of soil organisms (BLACKITH

& BLACKITH, 1975; CURRY, 1978; WALTER, 1985), an effect of the extremes mull/mor, viz. deciduous/coniferous litter on species composition of soil organisms might be expected (NIHLGARD, 1971). However if we want to study the role of soil fauna in nutrient cycling at species level, it is better to compare more related ecosystems on different soils.

In coniferous forests the mesofauna is a quantitatively important part of the biotic soil component. Mesofauna species belong mainly to the collembolans and oribatid mites, both often reaching a very high abundance and diversity (PETERSEN & LUXTON, 1982). In order to investigate the functional role of complex communities pooling of species is required. Taxonomical and physiological criteria are often used to make a structural/functional division in soil mesofauna, related to their function in soil processes (VISSER, 1985, VERHOEF & BRUSSAARD, 1990).

Functional classification of collembolans (CHRISTIANSEN, 1964; BÖDVARSSON, 1970, VERHOEF & BRUSSAARD, 1990) and oribatids (BUTCHER *et al.*, 1971; LUXTON, 1972) is often based on their gut content. Others used the shape of the mouthparts, the chelicerae, for a functional classification, because these mouthparts are adapted to the specific feeding habit (HARTENSTEIN, 1961; SWIFT *et al.*, 1979). Since species appear to adjust their feeding habits according to the decomposition state of the medium in which they are living (ANDERSON, 1975), all these divisions must be seen as rather rigid classifications. Oribatids are divided in microphytophagous, macrophytophagous, and panphytophagous (BUTCHER *et al.*, 1971; LUXTON, 1972, 1975; KANEKO, 1988), the first two groups being the specialistic feeders and the last group being the non-specialists. For collembolans the same division can be made; each group has its specific contributors, but most authors reckoned them as being mainly microphytophagous (CHRISTIANSEN, 1964). GISIN (1943) made a structural classification for collembolans on the principal of their ecological place in the organic horizon and their morphology. He distinguished epigeic, hemiedaphic, and euedaphic species. It is shown that the epigeic and the hemiedaphic species feed on fungi, while euedaphic species feed more on different food sources (POOLE, 1959, 1961; BÖDVARSSON, 1970; VISSER, 1985). Also for oribatids it has been suggested that the vertical distribution is related to their food preference (HAARLØV, 1955) and their body size (ANDERSON, 1975); the smallest species live deepest in the soil and are microphytophagous (LUXTON, 1972; WALTER & NORTON, 1984).

Comparison of the contribution of these functional groups of mesofauna to soil processes in different ecosystems can be done on the bases of a species diversity index (ANDERSON, 1978), on numbers of specimens and on arthropod biomass in functional groups (ANDERSON *et al.*, 1985). In this study we have compared the mesofauna populations in two monocultures of Austrian pine, planted on different soils. A comparison is made on the basis of species abundance and species biomass, and on the basis of different functional classifications in which much attention is given to their vertical distribution and to their feeding preference. This study was done with the aim to relate arthropods species distribution to differences in forest characteristics.

2. Materials and methods

2.1. Characteristics of sample areas

Both forests are *Pinus nigra* (ARN.) var. *austriaca* (A. et G.) forests. Forest I is 70 years old and planted on old sanddunes near the seacoast on the island of Schiermonnikoog in the north of the Netherlands. Forest II is 35 years old and planted on alluvial sand in the Dutch Flevopolder, in the middle of the Netherlands. Both forests are more or less monocultures of pine, and an understory is lacking.

To characterize both forests, nutrient content of the litter (table 1), litter and soil *p*H (table 1), litter standing crop (table 2), tree number density (table 2), and macrofauna presence were determined. For measurements on nutrient content litter from the F1-layer (*sensu* KENDRICK, 1959) was used.

Total nitrogen and carbon content of the litter were determined by burning the samples with pure oxygen and separating the gaseous compounds by column chromatography (KIRSTEN, 1979) using a Carlo Erba Strumentazione elemental analyser (model 1106). Litter total K, Ca, Mg, PO_4, and SO_4 contents were measured after digestion using a $HNO_3 : HClO_4$ (7 : 1) mixture, reducing the digestion liquid by evaporation, and dissolving the pellet in 0.1 *M* nitric acid. K, Ca, and Mg were measured using a flame atomic absorbance spectrophotometer (Perkin-Elmer 4000). Ca and Mg were measured in a 1% $La(NO_4)_2$ sollution. PO_4 and SO_4 were measured using an autoanalyzer (Skalar SA 400). The *p*H had been previously measured in the potassium chloride filtrates. Soil for *p*H measurement was sampled 5 – 10 cm below the humus layer. The *p*H was measured after 5 g soil had been shaken (75 rpm) for 2 h in 25 ml 1.0 *M* potassium chloride. Data shown in table 1 are the means over the sampling occasions. To determine litter standing crop and thickness of the litter layers, the litter was divided in a L- and F-layer (*sensu* KENDRICK, 1959), and the dry weights of the L- and F-litter were measured. This was done to know the space for living of mesofauna and to get some indication of the rate of the decomposition process in both forests. Dry weight of the litter was measured after drying for 3 days at 60 °C. The mean (n = 10) number density of trees was determined by counting them on a circular area with a radius of 5 m. As the forests are plantations the trees are more or less even aged and of the same size.

Table 1. Nutrient content (%) of Fl-litter and *p*H of litter and soil.

	Forest I mean ± sd	Forest II mean ± sd
Ca	0.54 ± 0.07	0.68 ± 0.08
Mg	0.15 ± 0.02	0.11 ± 0.03
PO_4-P	0.07 ± 0.00	0.06 ± 0.00
SO_4-S	0.16 ± 0.02	0.18 ± 0.04
N	1.62 ± 0.10	1.67 ± 0.11
C	52.22 ± 0.78	52.04 ± 1.18
C/N ratio	32.2 ± 0.11	31.2 ± 0.12
C/P ratio	746 ± 10.0	867 ± 13.2
*p*H KCl litter	4.21 ± 0.26	4.64 ± 0.43
*p*H KCl soil	4.86 ± 0.74	7.56 ± 0.02

Table 1 shows signifcant differences in the *p*H of litter ($p < 0.01$) and soil ($p < 0.001$), both being higher in forest II. The high *p*H of the soil of forest II nearly not influenced the *p*H of the litter; a typical effect of coniferous forests on basic soils. Forest II litter has a significantly higher Ca ($p < 0.001$) and SO_4 ($p < 0.01$) content, and a lower Mg ($p < 0.001$) and PO_4 ($p < 0.001$) content. Nevertheless, the C/N ratio of both forests is above 27, and the C/P ratio above 600, so that both forests are classified asforests with mor litter types.

Table 2 shows that although there is no difference in tree stand density, significantly more litter is found in forest I. This is shown by the depth of litter layers, especially the F-layer, both in May and August, and for the dry weight of F-layer material. Assuming a similar litter input in both forests, this means that the decomposition rate is highest in forest II and that in this forest the living space for mesofauna is less.

An indication of macrofauna number density was obtained by ten samples of 625 cm^2 of the litter layers and the upper 20 cm of the soil, which were hand sorted. In forest I only earthworms were found (35.2 ind. m^{-2}). In forest II a higher number of earthworms was found (51.2 ind. m^{-2}), together with other macrofauna species, such as isopods (11.2 ind. m^{-2}) and diplopods (9.6 ind. m^{-2}). With regard to the C/N ratio both forests belong to the mor type. From the other data it can be concluded that forest I showed the best the characteristics of a mor type soil, viz. a relatively low Ca content, a relatively low *p*H, a

Table 2: Litter standing crop and tree stand density.

		Forest I mean ± sd	Forest II mean ± sd
depth of litter in May (cm)	L	2.20 ± 1.00	**3.32 ± 1.35** p^{**}
	F	**8.36 ± 2.21**	4.80 ± 2.33 p^{***}
	L + F	**10.56 ± 1.94**	8.12 ± 1.76 p^{***}
depth of litter in August (cm)	L	3.39 ± 0.51	2.96 ± 1.16 p^{ns}
	F	**4.69 ± 1.55**	3.35 ± 0.94 p^{*}
	L + F	**8.08 ± 1.63**	6.31 ± 1.79 p^{*}
dry weigth of litter in August (g/m^2)	L	14.16 ± 0.25	14.23 ± 0.19 p^{ns}
	F	**18.02 ± 0.82**	15.73 ± 0.95 p^{***}
number of trees per ha		2020 ± 414	1900 ± 174 p^{ns}

Note: Column p gives the significance of the differences between the forests: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, ns not significant; when differences are significant the highest value is given in bold types.

high litter standing crop, and absence of macroarthropods. In forest I a more compact and more stratified litter layer could be seen, with a relatively low decomposition rate. Forest II seems to be a mor type forest which is, for some characteristics, on the way to a moder type, due to its basic mineral soil.

2.2. Mesofauna sampling

Mesofauna sampling was carried out in early May and late August 1987 for both forests. These sampling periods were chosen to obtain an indication of animal abundance both at the time of spring/early summer reproduction and late summer/autumn reproduction (ANDERSON, 1988). Sampling in forest II was 2 weeks earlier than in forest I. This division was made because forest I is situated 125 km to the north of forest II, and thus seasonal differences would be minimized. On each sampling occasion 25 random soil cores to the depth of the whole litter layer were taken. The cores enclosed an area of 72.54 cm^2. Cores were extracted for 10 days using Tullgren-type equipment. Animals were collected in a preservative prepared according to GISIN (1960). Details of the sampling method have been given in VAN STRAALEN (1985). Using a stereo microscope animals were divided in taxa, mostly to species or family. They were counted and their body lengths were measured. These body lengths were used to determine a specific length-weight relationship for the most abundant taxa. This relationship was used for the calculations of animal biomass. As a test using 30 *Orchesella cincta* (L.) showed that the animals lost 15% of their dry weight after 3 weeks in preservative (TEUBEN & SMIDT, unpublished data), the lenght weigth relationship was not based on specimens from the preservative but on live specimens.

Length was determined for collembolans as a straight line between the implant of the antennae and the anal papillae in lateral view (PETERSEN, 1975). As for some species the head is not in a straight line with the body, viz. *Lepidocyrtus*, *Tomocerus* and *Orchesella*, these were measured between the frons and the anal papillae. For mites the length was measured as a straight line from anterior to posterior. To correct for swelling whilst in preservative (VAN STRAALEN, 1989) the collembolan length was corrected for a 'swell factor'. For mites, this swelling is neglected as they have a strong exoskeleton. Dry weight was determined after freeze drying for a minimum of 16 h.

Differences between the data sets for both forests were analysed with Student's t-Test, following a F-test for homogeneity. Mesofauna data were first analysed for animal number and animal biomass per taxon. Secondly the taxa were lumped into functional groups; for collembolans following the classification of lifeforms of GISIN (1943). For mites a functional classification was made firstly on the basis of their body length and on the form of their chelicerae, and secondly using literature data on food choice (HARTENSTEIN, 1961). Since the functional groups are assigned on a subjective basis and the data are complex values the differences between the contribution of the functional groups in both forests (tables 4 & 5) are tested by the non-parametric Mann-Whitney U-test.

3. Results

3.1. Mesofauna numbers and biomass

The summation of the numbers and biomass of all collembolans and mites for the two forests in May and August is shown in table 3. Total mesofauna numbers in May and August show only small differences; only collembolan numbers in forest II increase in August. Significant differences between both forests are found only in August for collembolans ($p < 0.01$), and are more than 50% higher in forest II. Mesofauna total biomass shows more differences for May and August. Collembolans biomass seems to increase, as mites biomass decreases. No significant difference appears in total mesofauna biomass between both forests.

Table 3. Mean total number and biomass (mg) of mesofauna per m^2.

	May		August	
	Forest I	Forest II	Forest I	Forest II
numbers				
Collembolans	27,100	28,700	29,730	**46,990**
Oribatids	47,200	44,880	48,950	42,380
biomass				
Collembolans	221	170	388	522
Oribatids	308	207	238	169

Note: for legends see Table 2.

Fig. 1 shows the numbers and biomass for the different taxa of collembolans and oribatids found in forest I and forest II in May and August. A clear difference in abundance can be seen. In forest I, in May, one collembolan species, *Lepidocyrtus lanuginosus*, is abundant, while for August no clear dominance can be seen. At that time *Tomocerus minor* becomes more important, especially for collembolan biomass. Forest II also shows one abundant collembolan species in May, *Isotoma notabilis* and no clear dominance in August. *Tomocerus minor* seems to be the only important species for collembolan biomass in August.

The oribatid numbers in May and August in forest I are dominated by the group Eremaeidae. This is also true in forest II, but here in May also *Platynothrus peltifer* and in August the juveniles reach high numbers. Looking at the oribatid biomass in forest I in May four taxa have a considerable contribution: Camisidae, *Phthiracarus piger*, *Platynothrus peltifer*, and *Hemileus initialis*. In August in forest I two main taxa are seen: *Hemileus initialis* and Camisidae. In forest II in both May and August, one mite species only is important for biomass: *Platynothrus peltifer*.

3.2. Numbers and biomass in functional groups

The numbers and biomass of collembolan taxa are lumped into epigeic, hemiedaphic and euedaphic species, following GISIN (1943). In the two forests the epigeic group consists of the Sminthuridae and *Lepidocyrtus lanuginosus*; the hemiedaphic group of *Orchesella cincta*, *Neanura muscorum*, *N. spec.*, *Isotoma notabilis*, *Tomocerus minor*, *T. vulgaris*, *Hypogastrura spec.*, Poduridae and *Lepidocyrtus cyaneus*; and the euedaphic group of the Neelidae and *Isotomiella spec.*

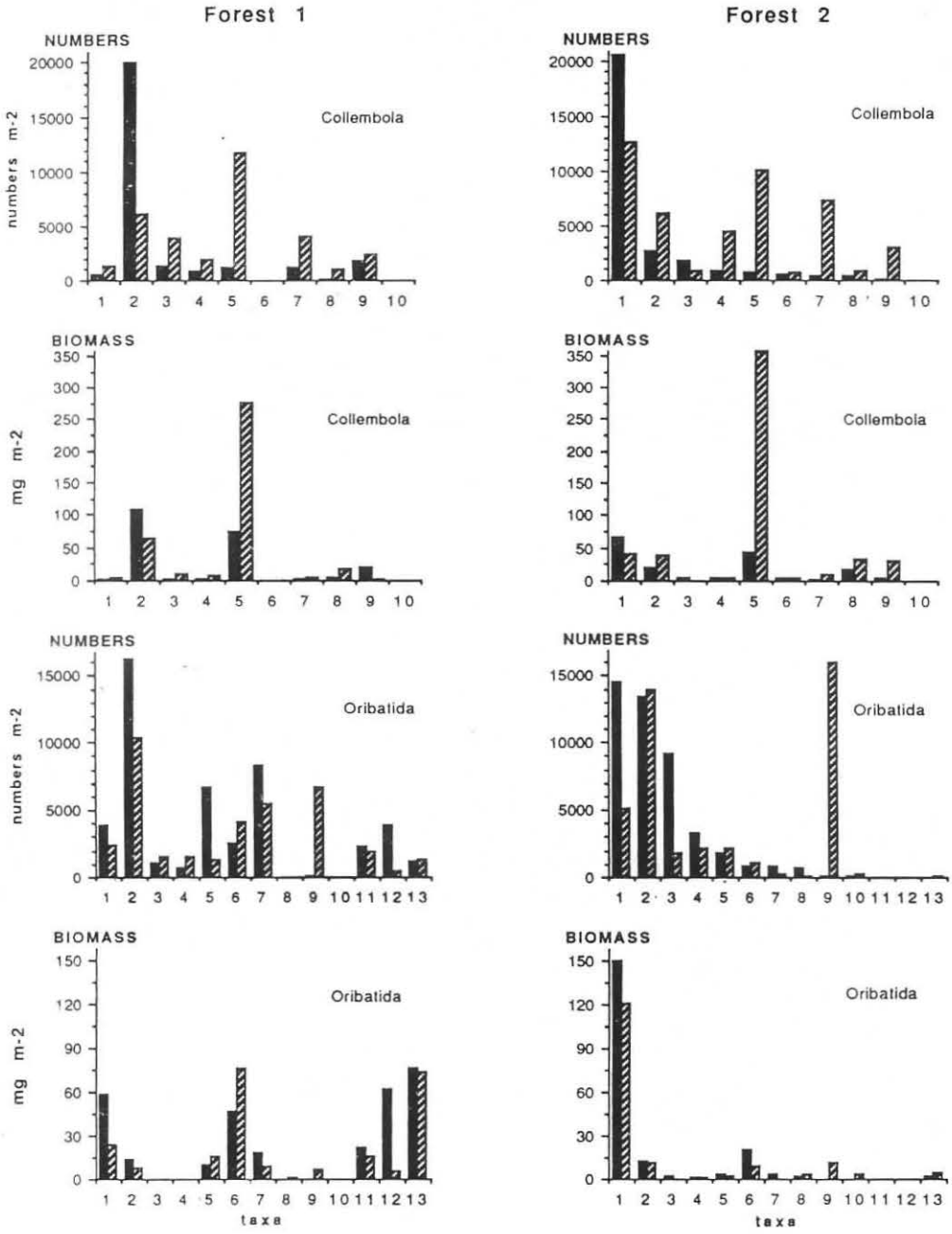
Forest 1
Forest 2
NUMBERS
BIOMASS
numbers m-2
mg m-2
Collembola
Oribatida
taxa

Fig. 1. Numbers and biomass (mg) of collembolans and oribatid mites in both forests per m^{-2}. Data are given in separate subfigures. Black columns show the results from the May sampling, and the shaded columns from August.
Collembolan taxa: 1. *Isotoma notabilis*, 2. *Lepidocyrtus lanuginosus*, 3. *Isotomiella spec.* + *Poduridae*, 4. *Sminthuridae*, 5. *Tomocerus minor* + *Tomocerus vulgaris* (only in forest I), 6. *Lepidocyrtus cyaneus*, 7. *Neelus spec.*, 8. *Orchesella cincta*, 9. *Hypogastrura spec.* + *Neanura muscorum* + *N. spec.*, 10. *Entomobrya nivalis* + *E. corticalis*.
Oribatid taxa: 1. *Platynothrus peltifer*, 2. *Eremaeidae*, 3. *Liochthonius brevis* + *L. peduncularis*, 4. *Brachychthoniidae* juveniles, 5. *Tectocepheus* juveniles, 6. *Hemileus initialis* (forest I)/ *Chamobates schützi* (forest II), 7. *Tectocepheus velatus*, 8. *Trichoribatus trimaculatus*, 9. unidentified juveniles, 10. *Oribatella quadricornuta*, 11. *Carabodes labyrinthicus*, 12. *Phthiracarus piger* + *Steganacarus strictulus*, 13. *Camisia spinifer* + *C. exuvialis*.

Table 4 shows that both in May and August in forest I the epigeic collembolan species are significant higher in number and biomass, while forest II shows significantly higher numbers and biomass for hemiedaphic species in May and August. No significant difference is found for the euedaphic species.

Numbers and biomass of oribatid mites are also lumped into functional groups. They are classified in microphytophagous, panphytophagous and macrophytophagous species according to their body lenght and the form of their chelicerae (SWIFT *et al.*, 1979).

Table 4. The contribution of functional groups of collembolans as a % of the total number c.q. biomass of collembolans in two pine forests.

	May		August	
	Forest I	Forest II	Forest I	Forest II
numbers				
epigeic	**76.8**	12.6***	**29.4**	18.5***
hemiedaphic	13.6	**79.1*****	53.7	65.8^{ns}
euedaphic	9.6	8.3^{ns}	16.9	15.7^{ns}
biomass				
epigeic	**49.4**	16.6***	**19.4**	7.0***
hemiedaphic	48.1	80.0^{ns}	77.4	**89.8*****
euedaphic	2.5	3.3^{ns}	3.6	3.2^{ns}

Note: Significance of differences tested with Mann-Whitney U-test (for legends see table 2).

Table 5. The contribution of functional groups of oribatids as a % of the total number c.q. biomass of orabitids in two pine forests.

	May		August	
	Forest I	Forest II	Forest I	Forest II
numbers				
macrophytophagous	**8.4**	0.0*	**1.0**	0.0
panphytophagous	34.0	37.8^{ns}	41.2	50.6
microphytophagous	57.7	62.2^{ns}	57.8	49.4
biomass				
macrophytophagous	**20.2**	0.0*	**2.9**	0.0
panphytophagous	64.8	**91.0***	80.2	**88.5**
microphytophagous	**15.1**	9.1**	**17.0**	11.5

Note: significance tested with Mann-Whitney U-test (for legends see Table 2).

Phthiracarus piger and *Steganacarus strictulus* belong the macrophytophagous species; *Camisia spinifer*, *C. exuvialis*, *Platynothrus peltifer*, *Oribatella quadricornuta*, *Hemileus initialis*, *Chamobates Schützi*, *Tectocepheus velatus*, *Trichoribatus trimaculatus* and the unidentified juveniles to the panphytophagous species; and *Carabodes labyrinthicus*, *Tectocepheus sp.* (juveniles), Brachychthoniidae *Car. sp.* (juveniles), Eremaeidae *(Suctobelba subtrigona*, *Thyriosoma lanceolata*, *Oppia ornata*, *O. nova)*, *Liochthonius brevis* and *L. peduncularis* to the microphytophagous species.

Table 5 shows significantly higher numbers and biomass in forest I of the specialist, the macrophytophagous and microphytophagous oribatid species, both in May and August. In forest II in August significantly higher panphytophagous numbers and biomass are found.

4. Discussion and conclusions

In a mor soil a higher habitat diversity can be expected due to the relatively higher litter standing crop and the stratified litter layers. HAARLØV (1955) and POOLE (1961), for collembolans, and ANDERSON (1978) and LUXTON (1981), for mites, have shown that the vertical distribution of mesofauna is related to this structural diversity of the litter layer. In particular the pore sizes within the litter are important. Forest characteristics in this study showed that with regard to the C/N and C/P ratios, both forests must be classified as mor forests, but that for other characteristics as litter structure, macrofauna presence and *p*H, forest II can almost be seen as a moder forest. Therefore, in forest I, the mor forest, a more diverse mesofauna may be expected when compared to forest II, the mor/moder forest.

In this study this has been found for both collembolans and oribatids, both in species composition and for functional groups. In the mor/moder forest, the dominant collembolan species, *Isotoma notabilis* belongs to the hemiedaphic group which is significantly the most important group both in total numbers and in biomass. In the mor forest the dominant collembolan in May, *Lepidocyrtus lanuginosus* belongs to the epigeic group, which group shows significantly higher numbers. Significant differences between the euedaphic groups in both forests are not found, which may be due to the sampling method: to prevent contamination with sand, the soil cores were cut halfway the humus layer. Both the numbers and biomass of collembolans and oribatids found in this study are similar to numbers and biomass recorded from a spruce forest in Germany (SCHAUERMANN, 1986).

For the oribatids it appears that the very small, eremaeid species are numerous group in both forests. It is known for another important species, *Platynothrus peltifer*, that this species is most numerous in moder and mull type soils (BERTHET, 1967). This is here also seen in the mor/moder forest, where this species is very dominant. In May *P. peltifer* forms about 70% of the total oribatid biomass, whereas in forest I this is only 19%. Looking at the functional groups, it can be seen that the intermediate group, the panphytophagous species, is significantly more abundant in the mor/moder forest, while in the mor forest the specialists with reference to food choice, the macrophytophagous and microphytophagous species are more abundant. So, beside the pore sizes, the feeding preferences of the different species can be an explanation for their stratification.

Collembolans are widely seen to be fungivorous (POOLE, 1959; CHRISTIANSEN, 1964; BÖDVARSSON, 1970), particularly the surface dwelling species (BÖDVARSSON, 1970; VISSER 1985) such as the dominant species in the mor forest *Lepidocyrtus lanuginosus*. Deeper living collembolan species such as the dominant species in the mor/moder forest *Isotoma notabilis* have a more variable gut content (BÖDVARSSON, 1970). With mites it is known that the smaller species like the Eremaeidae and the *Tectocepheus* and Brachychthoniidae juveniles, are mainly microphytophagous (LUXTON, 1972; WALTER & NORTON, 1984), and these are shown to be very numerous in the mor forest. *Platynothrus peltifer*, the most important species in the mor/moder forest, belongs to the panphytophagous group. These findings are in concurrence with the fact that in mor soils fungi are relatively abundant.

Another result of this study is the occurrence of the macrophytophagous oribatids *Phthiracarus piger* and *Steganacarus strictulus* in forest I only. Feeding on needles and wood (PANDE & BERTHET, 1973), they appear to replace in this aspect partly the absent macroarthropods in this mor forest.

We conclude that although both forests in this study show close resemblance being both mor type forests, small differences in forest characteristics exist and that these differences are reflected in arthropod species composition. In forest I species composition is in agreement with what might be expected in a mor soil; relatively high diversity in living space and relatively abundant fungi resulting in a mesofauna community with a dominance of specialistic feeders such as collembolans and mites which have a high preference for fungal food, and macrophytophagous oribatids. In forest II, a mor/moder soil with less diverse litter layers and relatively less fungi, the non-specialistic species are dominant. The same conclusion is even more obvious when we look at the biomass of the different groups (*cf.* SCHAUERMANN, 1986). This stresses the importance of determining faunal biomass. At the level of ecosystem processes animal biomass is more important than animal numbers, e.g. in animals contribution to nutrient cycling (ANDERSON *et al.* 1985). We have demonstrated significant differences between both forests in mesofauna species abundance and between functional groups of collembolans and oribatids. It is difficult to find differences between the forests when all collembolans and all oribatids are lumped into two groups. This means that the laborious job of going through a sample and counting the separate species cannot be replaced by simple determining the weight of rough groups. Forming functional groups must be based on minute counting and/or weighing of separate species.

A few restrictions for the use of animal biomass must be made. The relative contribution of animals to soil processes is not always in a straight relationship with their biomass. For example some mites have a relative heavy exoskeleton (PETERSEN, 1975), which is inert in most soil processes; also the metabolic activity of juveniles and adults (BERTHET, 1967), and between different functional groups are not necessarily the same for equal biomass (LUXTON, 1975). Comparing the data from spring and late summer, it is obvious that the contribution of the collembolan *Tomocerus minor* in particular becomes significantly more important; in spring in both forests one collembolan species is dominant, while in late summer dominance is distributed over more species. With biomass it is the other way round; spring shows a diverse distribution, while in late summer one species, viz. *Tomocerus*, is dominant in both forests. The dominance order for oribatid number and biomass is less changed from spring to late summer. In both forests the contribution of juveniles is significantly higher in late summer. WHELAN (1985) and SCHENKER (1986) have both found a summer peak of juvenile mites. VAN STRAALEN (1989) recorded a relatively high abundance and biomass of *Tomocerus minor* in August. The humid climat during the year of sampling possibly favoured *T. minor* [JOOSSE 1981; VEGTER *et al.*, 1988].

This study was a first step to test the hypothesis that arthropod species and biomass distribution was related to small differences in forest characteristics. We have studied this in two relatively homogeneous sites. Of course the next step must be a test with more sites, including polluted sites for example.

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Appendix

To determine the biomass, the relationships between bodylength and weight are given by BERTHET (1967) and PETERSEN (1975). BERTHET (1967) did not discriminate between different mite species, and PETERSEN (1975) made this relationship on the basis of animals' fresh weight. But LUXTON (1975) showed a variable water content for species. So, we constructed a length/weight relationship on the basis of the animals'dry weight. For the most abundant collembolan and oribatid species these relationships are given in the formula: log W = a.log L, where 'W' stands for animal dry weight, 'L' for bodylenght, and 'a' is a constant value.

The relationship between the dry weight and the bodylength of the most abundant collembolan and oribatid species; 'y' stands for dry weight in µg, 'x' stands for bodylength in units of 0.05 mm:

collembolans		**oribatids**	
Lepidocyrtus cyaneus	$y = 0.025 \cdot x^{2.060}$	*Platynothrus peltifer*	$y = 0.004 \cdot x^{3.112}$
Lepidocyrtus lanuginosus	$y = 0.026 \cdot x^{2.088}$	*Tectocepheus velatus*	$y = 0.007 \cdot x^{3.161}$
Tomocerus minor	$y = 0.009 \cdot x^{2.435}$	Camisiidae	$y = 0.036 \cdot x^{2.353}$
Orchesella cincta	$y = 1.000 \cdot x^{2.705}$	*Hemileus/Chamobates*	$y = 0.134 \cdot x^{2.009}$
Isotoma notabilis	$y = 1.000 \cdot x^{3.417}$	*Carabodes labyrinthicus*	$y = 0.358 \cdot x^{1.400}$
Onychiuridae	$y = 0.645 \cdot x^{0.546}$	Phthiracaridae	$y = 0.073 \cdot x^{2.377}$
Sminthuridae	$y = 0.070 \cdot x^{1.908}$	*Tectocepheus Gen. sp.* (juveniles)	$y = 0.290 \cdot x^{1.002}$
Hypogastrura spec.	$y = 1.000 \cdot x^{4.412}$		